DEPARTMENT OF NATIONAL DEFENCE
CANADA

OPERATIONAL RESEARCH DIVISION

**DIRECTORATE OF OPERATIONAL RESEARCH (JOINT & LAND)**

**ORD PROJECT REPORT PR 9913**

# NEW ARMY MAJOR RESEARCH AND DEVELOPMENT PROJECTS FY 99/00 AND FY 00/01: PRIORITIZATION

**BY**

**Ms. M. Halbrohr**

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Ms. M. Halbrohr

Recommended by: _____
G. Dufond
DOR(J&L)

Approved by: _____
A.P. Bradfield
DGOR

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## ABSTRACT

This report documents the prioritization of six new major research and development (R&D) projects by the Army Research Working Group (ARWG) in May 99. The "voting" exercise was conducted using the Consensus Decision Support Program (CDSP) methodology.



## RÉSUMÉ

Ce rapport documente l'analyse utilisé en Mai '99 pour établir l'ordre prioritaire de six nouveaux projets en matière de recherche et dévelopment pour le Groupe de travail pour la recherche – Armée de terre. L'exercise du scrutin a été à l'aide du CDSP.




## EXECUTIVE SUMMARY

1. At the Army Research Working Group (ARWG) meeting of 5 May 99 (Reference A), Chief Research and Development (CRAD) representatives briefed that the Defence Research Development Board (DRDB) resource allocation was $28 million for FY99/00 and $27.5 million for FY 00/01. The current over-programming was reported to be 15% in FY99/00 and 50% in FY00/01. Thirteen new major research and development (R&D) project starts were being proposed for FY 99/00 and FY 00/01. Six of these proposed starts were Army projects.

2. In order to help address these resource issues, direction was given at the 5 May ARWG meeting that the six new major Army R&D projects were to be prioritized using the consensus decision support program (CDSP) methodology. Due to the need to present the results at the next Research and Development Executive Committee (RDEC) meeting, the deadline for results was set for 21 May 99.

3. Implementing the "voting" procedure in such a short time frame was a challenge. Severe time constraints made it impossible to implement the CDSP methodology as it should properly be implemented. Shortcuts were taken which would have been avoided had more time been available. Shortcuts were taken in defining the criteria to be used for the ranking, in preparing project descriptions, in briefing "voters", in the "voting" process, in the subsequent analysis of the "voting" results, and in the building of consensus and "buy-in" among "voters". It was hoped that "voter" knowledge and experience, as well as "voter" requests for information should any item need clarification, would be able to overcome any shortcomings in the process which resulted from the shortcuts. Fortunately, this was the case and the prioritization exercise was a success. The process, although rushed, provided a ranking of the projects which was acceptable to the co-chairs of the ARWG and was presented to and used by the RDEC.

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# NEW ARMY RESEARCH AND DEVELOPMENT PROJECTS FY 99/00 AND FY 00/01: PRIORITIZATION

## I. INTRODUCTION

1. At the Army Research Working Group (ARWG) meeting of 5 May 99 (Reference A), Chief Research and Development (CRAD) representatives briefed that the Defence Research Development Board (DRDB) resource allocation was $28 million for FY 99/00 and $27.5 million for FY 00/01. The current over-programming was reported to be 15% in FY 99/00 and 50% in FY 00/01. Thirteen new major research and development (R&D) project starts were being proposed for FY 99/00 and FY 00/01. Six of these proposed starts were Army projects.

2. In order to help address these resource issues, direction was given at the 5 May ARWG meeting that the six new major Army R&D projects were to be prioritized using the consensus decision support program (CDSP) methodology. The choice of methodology was based on its familiarity to some members of the ARWG and on its earlier success in prioritizing equipment goals for the Land Force Equipment Strategy (LFES) I (Reference B). Director Operational Research (Joint and Land), (DOR(J&L)), was present at the ARWG meeting and he stated that CDSP was indeed an appropriate methodology for the circumstances. On 6 May the author was informed that she was to provide the scientific advice, direction and analysis required to complete the R&D project prioritization. No "heads-up" had been given prior to 6 May that this tasking was in the offing. The deadline for results was 21 May.

## II. REPORT AIM

3. The aim of this report is to document how the R&D project prioritization process was conducted, how successful it was, and the lessons learned from its implementation. This report will:

a. serve as the corporate memory for how the May 99 new major Army project prioritization exercise was implemented;

b. act as a valuable reference should the decision be made to use the CDSP methodology in future R&D project prioritization exercises; and

c. impart important lessons learned to other scientists who may need to implement the CDSP methodology in situations in which tight time limits severely constrain how the methodology can be implemented.



## III. APPROACH

4. At the time of the tasking, on 6 May 1999, DOR(J&L) gave the following direction:

a. the sponsor representative and main point of contact was to be the ARWG secretary, Maj. JW Willis;

b. the clients were the co-chairs of the ARWG;

c. the 21 May 1999 deadline for results was firm due to the need to present the results at the next Research and Development Executive Committee (RDEC) meeting;

d. the six new major Army projects to be ranked did not yet have descriptions of them written up but the ARWG had issued a direction that the descriptions were to be provided within one week;

e. the ARWG had directed that the criteria used for the LFES I ranking exercise should form the basis for the criteria to be used for the R&D project prioritization; and

f. there would be no face to face meetings with all personnel involved in the ranking process. The prioritization exercise was to be conducted via e-mail and telephone.

5. At the time of the tasking, the following information was also imparted:

a. some members of the ARWG had experience with CDSP whereas others had no knowledge of it;

b. there were differing levels of comfort and agreement within the ARWG in terms of how the resource issues were to be resolved and whether it was a good idea to rank the six new major projects using CDSP. It would be beneficial if time could be taken to encourage "buy-in" into using the CDSP process, and to develop consensus and acceptance of the CDSP generated results; and

c. an "80%" solution delivered on time would be of great assistance to the ARWG. A "100%" solution delivered late would be of no use.

6. At the first meeting with the sponsor representative on the morning of 6 May, the sponsor's "problem" was further defined, the CDSP methodology was explained and demonstrated, and the sponsor was frankly advised that implementing the CDSP "voting" procedure in such a short time frame was a great challenge. The sponsor was told that the "voting" exercise would definitely yield useful results, but due to time constraints, it may or may not yield an acceptable prioritization of the projects. An example where the first round results would not be acceptable is the case where there is a great deal of disagreement among "voters". In such a case, a second round of "voting" would be required; a round that would need to be conducted after "voters" had developed a greater degree of consensus through discussions of the first round results and the contentious issues. But for the R&D project prioritization, time constraints would not allow for a second round of "voting".

7. The sponsor was assured that whether or not the first round "vote" would result in a prioritization that is acceptable for presentation at the RDEC, implementing the CDSP methodology would definitely yield information valuable to the ARWG. This information could be useful for determining input to the RDEC even if the first round results were not acceptable. In particular, the first round "vote" would yield:

a. an indication of the degree of consensus among ARWG members on how the projects should be prioritized;

b. an indication of which projects are most contentious in terms of their priority;

c. knowledge of how each member of the ARWG would individually prioritize the projects;

d. a first-cut solution as to what criteria should be used in ranking new projects in the CRAD R&D program; and

e. a set of completed project definition forms for the six new major Army projects that contain most, if not all, of the critical information required for their prioritization.



8. It was explained to the sponsor representative that severe time constraints made it impossible to implement the CDSP methodology as it should properly be implemented. Shortcuts that would have been avoided had more time been available would need to be taken in applying the CDSP approach. Shortcuts were to be taken in defining the criteria to be used for the ranking, in preparing project descriptions, in briefing "voters", in the "voting" process, in the subsequent analysis of the "voting" results, and in the building of consensus and of "buy-in" among "voters". It was hoped that "voter" knowledge and experience, as well as "voter" requests for information should any item need clarification, would be able to overcome any shortcomings in the process which resulted from the shortcuts. In addition, the deadline would not allow for having "voters" meet and discuss the first round results and the contentious issues. It would also not allow for a second round of "voting" to take place, if it were required.

9. The scientist and the sponsor representative developed the following timetable:

a. identification and definition of the criteria to be used for ranking the projects, identification of the "voters" to participate in the "voting" exercise, and development of the format to be followed in preparing project descriptions, to be completed 7 May 1999;

b. first set of instructions requesting completed project descriptions in standardized format and containing a CDSP familiarization package to be issued 7 May 1999;

c. project descriptions to be due 17 May 1999;

d. project descriptions to be reviewed to ensure they are reasonably complete, information added to them if required, and their format to be standardized if not already done so, to be completed 18 May 1999;

e. second set of instructions asking for "votes" to be issued 18 May 1999;

f. "votes" to be due noon 20 May 1999;

g. generation of project prioritization based on "voter" inputs and CDSP, as well as analysis of results, to be completed 20 May 1999; and

h. the prioritized list of projects and a synopsis of relevant statistics and analysis/information to be provided to the ARWG co-chairs on 21 May 1999.

The above timetable was achieved in practice, with the exception that some "votes" weren't received until the morning of 21 May 1999 due to technical difficulties. The difficulties resulted from a recent change in e-mail software that made the "voting" instruction set unreadable to some "voters". The instructions had to be resent to these "voters" by fax and this resulted in a slight delay, but still allowed the 21 May 1999 deadline to be met.

## IV. PROJECTS TO BE RANKED

10. The following six new major Army R&D projects (listed in no particular order) were to be ranked in order of priority:

a. Project Serial Number 1 - Future Armour Vehicle Systems Technology Demonstrator;

b. Project Serial Number 2 - Hypervelocity Direct Fire Weapon System Technology Demonstrator;

c. Project Serial Number 3 - Protection from Blast;

d. Project Serial Number 4 - Stand-off Demolition Device;

e. Project Serial Number 5 - High Capacity Tactical Communications Network; and

f. Project Serial Number 6 - Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR).

## V. "VOTERS"

11. The CDSP approach allows each "voter" an equal voice in how the projects are to be prioritized. It is thus very important that the "voter" representation be reasonable and fair, and that all "voters" have the knowledge, experience and background to be able to make an informed ranking of all the projects. It should be noted that the CDSP approach does not allow any "voter" to abstain from ranking a project.

12. Initially, the proposed "voter" list consisted of all the ARWG members and of military staff who, although not ARWG members, would ensure that there was a better rounded representation of all combat arms during the "voting" process. However, ensuing discussion resulted in pruning the list of "voters" to including the ARWG members only. The pruned list was thought to be representative enough for "voting" purposes.

13. The "voters" designated to take part in the prioritization exercise were the members of the ARWG, namely:

a. Col CJR Davis, DLR;

b. LCol WL Pickering, A/DLSC;

c. Dr KN Ackles, SA Comd 1st Cdn Div;

d. Mr. G Lafond, DOR(J&L);

e. Mr. DL Smith, DSTL;

f. LCol BE MacDonald, DLERM 4;

g. LCol PG Ward, DLSP 2;

h. Maj JEVMM Moo-Sang, J2 STI 2-4-2; and

i. Col JJ Morneau, DAD.

## VI. RANKING CRITERIA

14. Agreement on the criteria to be used for ranking the projects is important for two reasons:

a. it provides guidelines to the "voters" on what factors are to be considered important and helps ensure that no important criteria are overlooked; and

b. it provides guidelines to those who are preparing the project descriptions, helping them to ensure that they provide all the information necessary for "voters" to make an informed decision on how to prioritize the projects.

15. The process of identifying the criteria to be used in ranking the projects was extremely rushed. It was completed in a matter of hours. The scientist and the sponsor representative first prepared a list of criteria based on the criteria used for the LFES I ranking exercise, making significant modifications and additions in order to make the equipment goal specific criteria more readily applicable to R&D project prioritization. In particular, LFES I criteria definitions were reworded so that they were in an R&D context and new criteria relevant to R&D projects were added and defined. The direction to base the criteria on that used for LFES I had been given by the ARWG.

16. After the draft list of criteria and their definitions was complete, it was shown to Mr. Saint and Mr. Lavigne who had kindly agreed, on extremely short notice, to provide input from a CRAD perspective. During this meeting, the proposed "voting" timetable and the proposed format for project descriptions were also discussed.

17. At this time, the criteria list was modified, and after much debate, it was agreed to delete the technological risk / uncertainty criteria from the list. The aim was to generate a list of criteria that was complete, accurate, reasonable, and well defined. The criteria definitions were fine tuned, but never reached the standard that would have been sought had more time been available to develop them. The outcome of the discussions was a list of criteria and their definitions which, although no one was completely happy with, was considered by all to be acceptable for use in the "voting" process given the constraints everyone was working under.

18. It was agreed that the following criteria were to be suggested for use in ranking the R&D projects (with the understanding that the list may not be all inclusive):

a. deficiency;

b. usefulness;

c. operational risk;

d. relevance to capital equipment programme;

e. technological investment strategy; and

f. operational / tactical level concepts.

As a point of interest note that the LFES criteria, which served as a starting point for developing the R&D criteria, included: deficiency, likelihood of use, operational risk, technological risk, and availability. Note also that although some of the criteria for the LFES and R&D prioritization exercises were named similarly, these criteria were not necessary identically defined.

19. The criteria used for the R&D project prioritization were defined as follows:

a. **Deficiency**. Deficiency is defined as the magnitude of the difference between the Army's current capability and the technological capability or knowledge that the R&D project is expected to demonstrate. "Voters" should consider the decisions that the project is designed to influence, the magnitude of the impact of the project on the Army's capability and its relevance to Army needs.

b. **Usefulness**. Usefulness is the likelihood that the technology or knowledge developed by the R&D project will be employable by the Army, possibly after some further development by industry or the DRDB, aggregated over the relevant DPG scenarios from the list below (which is not prioritized):

(1) peace support operations (chapter 6 - peacekeeping)
(2) national sovereignty and interests enforcement
(3) peace support operations (chapter 7 – peace enforcement)

(4) defence of Canadian and US territory, and
(5) collective defence

c. **Operational Risk**. Operational risk is defined as the risk to operations (including mission success and casualty rates) aggregated over all the scenarios considered above, if the deficiency is not resolved.

d. **Relevance to Capital Equipment Programme**. Is the technology or knowledge developed in the project relevant to the following projects in the Army capital equipment programme:

(1) Tactical Command, Control and Communications System
(2) Land Force Command System
(3) Light Utility Vehicle Wheeled
(4) Coyote
(5) Leopard Thermal Sight
(6) Position Determination and Navigation
(7) M113 Life Extension
(8) Improved Environment Clothing System
(9) Wheeled Light Armoured Vehicle Life Extension
(10) Armoured Personnel Carrier Replacement, Phases 1 and 2
(11) Tactical Battlefield Command System
(12) Armour Combat Vehicle
(13) Tactical Information Distribution Enhancement
(14) Counter-bombardment and Target Acquisition
(15) Land Tactical Electronic Warfare Equipment
(16) Medium Indirect Fire System
(17) Improved Protective Clothing and Equipment
(18) Very Short Range Air Defence
(19) Medium Logistic Vehicle Wheeled Replacement
(20) Tactical Command and Control Information System
(21) Light Support Vehicle Wheeled Replacement
(22) Precision Indirect Fire Capability
(23) Light Armour Vehicle Replacement
(24) Battlefield Combat Identification
(25) Leopard Replacement
(26) Coyote Life Extension

(27) Brigade Surveillance and Reconnaissance
(28) Vehicle Electronics (Vetronics)
(29) Unmanned Aerial Surveillance and Target Acquisition System
(30) Global Positioning System Replacement
(31) Automated Tactical Intelligence Support System
(32) Observer Target Acquisition System
(33) Minefield Clearance System
(34) Engineer Support Equipment
(35) Unit Surveillance, Target Acquisition and Night Observation
(36) Mortar Integrated Fire Control System
(37) Gun Position Technical Management System
(38) Artillery Data System
(39) Air Defence Command and Control Information System

e. **Technological Investment Strategy**. The technology investment strategy, at Reference C, defines the technological opportunities and outcomes that the DRDB expects to be important for the CF in the future if we are to maintain our technological advantage. Projects should support the following science and technology outcomes:

(1) Deployable covert, stealthy sensor systems with adaptable resolution and wide area coverage

(2) Rapid and reliable automated detection, identification, tracking and engagement of stealth targets

(3) Smart information and knowledge management and timely delivery for reliable and simplified decision making in a complex environment

(4) Robust, survivable and covert sensor and weapon systems for the 2020 war fighting environment

(5) Timely and accurate assessment of asymmetric threats (e.g. chemical and biological, information operations, etc) and effective countermeasures

(6) Re-configurable simulation systems for training of individuals and teams, mission rehearsal and acquisition

(7) Individual and collective protection, survivability and sustainability

(8) Rapid technology development, assessment and insertion (right systems available at the right time at the right cost)

(9) Lethality matched to mission with a wide range of potential weapons effects

(10) Adaptable operator tailored systems

Voting should take into consideration whether the project advances our knowledge in support of these outcomes.

f. **Operational / Tactical Level Concepts**. The capability of the R&D project to support the LFSDG, Reference D, operational and tactical concepts:

(1) Fuse data from a variety of sensors and sources

(2) Develop decision support tools to aid in the analysis of data

(3) Increase battlefield awareness by distributing data to the right level of command at the right time

(4) Integrate ISTAR assets into a cohesive system to achieve real time situational awareness

(5) Develop beyond line-of-sight recce and target acquisition capability

(6) Maintain battlefield mobility against the threat of precision weapons

(7) Improve survivability by developing early warning devices, stealth and effective countermeasures against precision attack weapons

(8) Improve situational awareness, particularly in built up areas

(9) Develop a modern and highly mobile protected direct fire system for close combat

(10) Develop more effective obstacle breaching resources

(11) Develop long range precision indirect fire munitions

(12) Develop automated command, control and intelligence systems for integrated fire direction and intelligence gathering

(13) Develop non line-of-sight indirect fire target acquisition resources

(14) Improve individual and vehicular protection

(15) Develop deception and stealth techniques and decoy

(16) Develop methods to deflect precision warheads

(17) Develop improved defences against flechette rounds and volumetric munitions

(18) Develop non-lethal anti-personnel and anti-vehicle obstacles

Voting should take into consideration whether the project advances our knowledge in these areas.

20. "Voters" were directed to not consider cost as one of the criteria.

21. The above criteria were provided as guidelines, but "voters" were told that the list was not necessarily complete and that it was up to the "voters" as to how, or if, they used the above criteria in their individual ranking of the projects. To cover the possibility that the list was incomplete, "voters" were strongly encouraged to ask for more information, or clarification, whenever it was needed.

22. No guidelines were provided as to the importance of each criterion. Each "voter" was asked to individually assess the divergent factors and trade-offs that go into the final decision as to how to prioritize the projects, based on his own knowledge, experience, and best judgement. This approach allowed for shortcomings in the criteria list to be overcome by "voter" expertise. It also illustrated one of the greatest strengths of the CDSP methodology - it allows human decision-makers to make the assessments and complex trade-offs in the prioritization process, without using any artificial weights or rating scales to provide a ranking solution.

23. Fortunately, the above criteria list coupled with "voter" knowledge and personal experience, was adequate for this particular "voting" exercise. During the "voting" process, not a single "voter" asked for information in addition to that provided in the instruction package. "Voters" were also asked for their inputs in terms of the criteria being used to rank the projects. Only one comment was received in response, asking why the technological risk / uncertainty associated with each project had not been considered. The lack of responses and questions concerning criteria and project specific information provides a strong indication that the criteria were not far off the mark. Thus, they can be used as a starting point for criteria definition if the decision is made to employ the CDSP in a future R&D project prioritization exercise.

24. In more ideal circumstances, the criteria identification process would have taken several days and would have included inputs from all "voters" and all stakeholders.

25. In refining the criteria for future R&D project prioritization, it is suggested that the following be taken into consideration:

a. it should be noted that the items in the technological investment strategy criterion do not include areas that are already being well addressed and which need to be kept up with (e.g. firepower). Such areas should also be listed for the benefit of "voters".

b. whether to include a technological risk / uncertainty criterion should be investigated. If it is included, thought needs to be given as to how to best address this topic for the benefit of "voter" information. As noted during discussions with CRAD representatives, research is inherently a "risky" proposition. The technological risk / uncertainty associated with a project is a complex topic. It is important that it be properly addressed so that those projects that are high risk but also provide high potential payoffs are not unduly penalized during the ranking process.

c. are the following adequately addressed within the criteria:

(1) Operational requirements considerations (both near term and strategic);

(2) International or Industrial Implications (e.g. International Agreement or Cooperative R&D);

(3) Strategic Technology Considerations;

(4) Support to In-Service Systems (i.e. Stretching Capability);

(5) Support to Canadian industry where they have genuine prospect for world sales;

(6) Joint projects that meet Canadian need and are supported by a business case;

(7) Support for unique Canadian requirements;

(8) How readily available is the scientific and technical expertise required by the project, either in-house or through contract;

(9) Impact of Not Doing the Project;

(10) Operational and Scientific / Technical Impact; and

(11) Support to Maintaining Core capability (level of effort (human and financial) which is needed to meet the department's present and future needs for advice and support).

26. Cost, cash phasing and programming considerations are likely best considered after the R&D projects have been prioritized, and not as part of the ranking criteria.

## VII. PROJECT DESCRIPTION SHEETS: CONTENT / FORMAT

27. Experience from earlier "voting" exercises showed that it is essential that the information package provided to "voters" be concise, complete, and accurate. The information package should be as brief as possible without omitting any information that is critical to the "voters". Project descriptions should follow the same format, with topic headings in bold, so that "voters" find it easy to compare two projects and to find the information they are seeking. These "motherhood" statements are often difficult to fully comply with, especially since a different author or set of authors usually writes each project description. Preparing the descriptions should ideally be an iterative process, and can be quite time consuming.

28. For the R&D project prioritization, deadlines did not allow the luxury of an iterative process. If essential information required by "voters" was missing from the project descriptions, it would be difficult to track down the missing information and provide it in a timely fashion to the "voters", given that "voters" would have only two days to review the information and provide their rankings. As such, it was important that clear and complete direction be given to staff who were to prepare project descriptions. Furthermore, CRAD representatives stressed that their staff were very busy, and as such, the workload to be asked of them in completing project descriptions in such a short timeframe should be minimized.

29. With the above view in mind, it was decided to ask that the R&D project descriptions be based on a reporting format that had already been set out by CRAD and which CRAD had already dictated be completed for each project by 14 May. This basic format was adhered to, with the exception that some important topics (e.g. project aim, project objective, project scope, addressing each of the "voting" criteria individually) were added to the CRAD generated format. This minimized replication of work and yet ensured that unique "voter" needs would be met.

30. DSTL Thrust Coordinators were requested to complete project descriptions for the six new Army major projects following a specified format. The format was:

Project Name
Project Aim
Project Objectives
Project Scope
Project Context
- what decisions is the project intended to influence
- what are the questions which must be answered
- what is the experimental plan to obtain answers
- what needs to be built/demonstrated to conduct experimentation

Project Framework
- timelines and linkages to CF/DND decisions
- DRDB resources
- contributions from other sources
- national and international collaboration opportunities
- participants

Project approval schedule
Issues / Comments
Address each criterion (see above) individually

31. It was asked that the project descriptions be limited in length. Project status and project results to date were not required, as all the projects to be ranked were new ones. Given the 14 May 1999 deadline to provide the project description input required by CRAD, it was felt that the 17 May 1999 deadline for input into the R&D "voting" exercise was fair if somewhat tight.

32. The project descriptions that were received were reviewed, and the formats corrected if need be, to ensure that the reports were more consistent. Unfortunately, the editing had to be done without consulting with the original authors. As such, editing was kept to a minimum, with only essential items being changed after phone consultation with DSTL, Mr. Smith, if necessary.

33. As expected, some descriptions were written up better than others. Some were not as strongly worded as they perhaps could have been. Some were missing information that others had included and which would have been useful to "voters". For example, some descriptions detailed not only which DPG scenarios, capital equipment programs, technological investment strategy outcomes, and operational / tactical level concepts the project would be relevant to, but also detailed how it would be relevant and the extent to

which it would be relevant. Other descriptions did not address the "how" and "why". They just provided the list of items thought to be relevant without any explanations or justification, as the direction provided to the authors had not specifically asked that the "how" and "why" be addressed. It is recommended that in subsequent uses of the CDSP for R&D project prioritization, those preparing the descriptions be asked for the "how" as well as the "which". In addition, time should (if possible) be given to an iterative process in preparing the descriptions, so that all descriptions are complete and reach the same standard.

## VIII. TEAMWORK

34. It was most fortunate that, despite the short notice, representatives were available from the R&D and the operational communities to lend their expertise into the formulation of the criteria list, of the project description format, and of the proposed "voting" timetable and approach. Their participation contributed a great deal to ensuring the completeness, accuracy and reasonableness of the instruction sets that were issued and also added credibility to the process.

## IX. FIRST INSTRUCTION SET

35. The first instruction set provided direction on why the prioritization exercise was to be conducted and how it was to be conducted. It provided users with a list of the projects to be prioritized, a list of "voters", the details of the timetable to be followed, the criteria and project description form being proposed for use in the exercise, and a description of the CDSP methodology consisting of briefing slides.

36. The instruction set asked:

a. DSTL Thrust Co-ordinators to complete the project definition forms for their projects with input from the Thrust Leader and Thrust Client Representatives. The reporting format to be followed was attached as an annex.

b. "Voters" to carefully review the description of the CDSP methodology which was attached as an annex. "Voters" were to ensure that that they understood how the process works and that the assumptions made by the methodology are reasonable for this particular ranking exercise. If "voters" had any concerns or questions, they were strongly encouraged to contact the ARWG secretary. Major concerns with the approach, project descriptions or the process were to be raised immediately. It was stressed that it is essential that everyone involved in the ranking exercise fully understand what is being done and why, and that they agree with the methodology.

37. The lack of consultation with "voters" and stakeholders was apologized for. It was explained that tight deadlines were forcing shortcuts to be taken which would have been avoided had time allowed. No questions or concerns were raised by any of the recipients of the first instruction set, other than one recipient having problems reading some of the files that were sent by e-mail. This technical difficulty was resolved by providing new copies of the files.

## X. SECOND INSTRUCTION SET

38. The second instruction set requested that "voters" individually prioritize the R&D projects which were to be ranked, and submit their prioritized lists along with optional comments on the reasons for their ranking choices and comments concerning the ranking process itself. The completed project description forms for each project, and a listing and definition of the criteria recommended for use, were attached to the second instruction set. "Voters" were reminded that in ranking the projects, a lower priority project is not a project that is unimportant. Rather, it is a project that is important but could be addressed after the projects that are ranked as higher priority have been addressed. "Voters" were once again strongly encouraged to contact the ARWG secretary should they have questions or a need to clarify some topic or receive additional information on a topic. In order for the exercise to succeed, "voters" needed to have access to all the information they felt was essential to provide an informed prioritization of the R&D projects.

39. In prioritizing the projects, the "voters" were asked to note the following:

a. ties and multiple ties are allowed.

b. due to the way in which the CDSP algorithm works, "voters" should exercise the same care in ranking the lower priority projects as they do in ranking those of higher priority. Briefing slides on CDSP were made available in the first instruction set, and a report on CDSP would be made available on request.

c. it is essential that "voters" take a corporate view as they "vote" – that is, "voters" should consider what is best for the Army as a whole.

d. it is essential that "voters" have sufficient knowledge and experience to be able to reasonably rank all the projects. "Voters" cannot abstain from ranking any project. The project definition forms attached to the instruction set provide information that is critical for the ranking exercise. The project descriptions are as complete and similar in format as time constraints allowed. However, if "voters" find that there is information that is needed and which is missing from the attachment, "voters" should not hesitate to contact the ARWG secretary. The aim of the instruction set

is to ensure that "voters" have sufficient knowledge for meaningful prioritization. Equal knowledge is not required.

e. the provision of comments as to why "voters" ranked the projects as they did is encouraged, but not necessary. These comments can be compiled to provide additional rationale for the prioritization results. "Voters" were also asked to list any criteria they used in addition to that suggested in the instruction set. They were also asked to provide any suggestions they had for changes to the criteria definitions or project-reporting format. This input was requested as it would assist if a decision were made to utilize CDSP in future R&D project ranking exercises. "Voters" were told that each "voter" would be given an equal voice in the prioritization process.

40. The instruction set explained to "voters" that once their individual prioritized lists were received, they would be input into the CDSP software. The software would then be used to determine dominances and coalitions for or against each alternative, and would combine "voter" inputs to produce a prioritized list of the projects. The list should reflect the combined informed best judgement of the "voters", representing both the R&D and the operational communities. In addition, the software would be used to produce statistics that indicate the degree of consensus among the "voters".

41. "Voters" were informed that normally they would be provided with the CDSP-produced list and asked to meet in order to discuss the "reasonableness" and "acceptability" of the CDSP-produced list and to debate contentious issues, if any. If warranted, a second round "vote" would be conducted, with the hope that the results of the first round "vote" and the subsequent discussion would have led to more consensus. However, time constrains did not allow for discussion by "voters" or for a second round. As such, the CDSP produced prioritized list, along with the statistics indicating the degree of consensus, were to be provided to the co-chairs of the ARWG. The co-chairs were to unilaterally assess the reasonableness of the result and the degree of consensus, and decide how (or if) to employ the CDSP-generated priority list. They were also to decide how to disseminate the CDSP results to the members of the ARWG.

42. During the "voting" phase, there were no requests for additional information and the "voters" raised no questions. The only problem encountered was a technical one, as some "voters" were not able to read some of the e-mail attachments that had been sent as part of the "voting" instructions. The problem was fixed by sending one "voter" a fax of the files, and providing another with the files on diskette.

## XI. RESULTS

43. The following information was provided to the co-chairs of the ARWG as a result of the first round of "voting":

a. a ranking of the projects in order of priority, as produced using the CDSP software (refer to Figure 1);

b. identification of the top two "most contentious" projects and a listing showing how each of these two projects had been ranked by individual "voters" (refer to Figure 2);

c. a listing showing how each "voter" had ranked each of the projects in order of priority (refer to Figure 3);

d. a matrix of rank correlation between players, providing an indication of the degree of "agreement / disagreement" between each pair of "voters" (refer to Figure 4); and

e. a comment stating that a statistically significant level of consensus exists.

44. Only two of the ten "voters" provided comments on why "voters" ranked projects as they did. It was decided not to compile these comments and not to include them as part of the results.

45. The ARWG co-chairs were to assess item (a) for reasonableness and decide whether it was acceptable for presentation to the RDEC. Due to deadlines, the co-chairs did not have the choice of conducting a second round of "voting". Their only choices were to accept the first round result as is, to accept it with modifications that they decided upon unilaterally, or to reject the first round result and find an alternate means of producing the answer required for the RDEC meeting.

46. The results presented to the ARWG co-chairs included "voter" names. However, for the sake of anonymity, the results presented in this report replace each "voter" name by a numeric "voter" identifier.

| Ranking | Project Serial Number |
|---|---|
| | |
| 1 (Highest Priority) | 5 (High Capacity Tactical Communications Network) |
| 2 | 6 (ISTAR) |
| 3 | 1 (Future Armour Vehicle Systems Tech Demo) |
| 4 | 3 (Protection from Blast) |
| 5 | 2 (Hypervelocity Direct Fire Weapon System Tech Demo |
| 6 (Lowest Priority) | 4 (Stand-Off demolition Device) |

Note: The CDSP program was used with the option that 6 was required for a majority.

**Figure 1: Ranking Generated Using CDSP and Input from 10 "Voters"**

| Project | Ranking by Individual "Voters" | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| #5 (High Capacity Comms) | 1 | 1 | 1 | 2 | 2 | 3 | 1 | 1 | 6 | 3 |
| #2 (Hypervelocity DF WS) | 2 | 4 | 6 | 5 | 2 | 5 | 5 | 5 | 2 | 2 |

Note: Had time allowed, "voters" should have been asked to meet and discuss the CDSP generated results, and possibly a second round vote would have been conducted. Projects #5 and #2 would have been discussed, with voters addressing why they were ranked so differently by individuals.

**Figure 2: Top 2 Most "Contentious" Projects**

**Rank** (Minus Sign Denotes Ties):

| Voter ID | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| | | | | | | |
| 1. | 5 | 2 | 6 | 1 | 3 | 4 |
| 2. | 5 | 6 | -1 | 3 | 2 | 4 |
| 3. | 5 | 6 | 1 | 3 | 4 | 2 |
| 4. | 1 | 5 | 6 | 4 | -3 | 2 |
| 5. | 1 | -6 | 5 | -3 | -2 | 4 |
| 6 | 3 | 6 | 5 | 1 | 2 | 4 |
| 7. | 5 | 6 | 3 | 1 | 2 | 4 |
| 8. | 5 | 6 | 1 | 3 | 2 | 4 |
| 9. | 1 | 2 | 4 | 3 | 6 | 5 |
| 10. | 6 | 2 | 5 | 1 | 4 | 3 |

Note on Interpretation of Ties: The items with minus signs are tied in rank to the item preceding them that has no minus sign. So, for example, "voter" #5 considers items 1 and 6 to be tied for highest priority, items 5, 3 and 2 to be tied for next highest priority, and item 4 to be of lowest priority.

**Figure 3: Ranking Of Projects by Individual "Voters"**

(Note: 1 denotes perfect agreement; the matrix shows pairwise agreement/disagreement between "voters")

Voter ID

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | 1.00 | | | | | | | | | |
| 2. | .55 | 1.00 | | | | | | | | |
| 3. | .47 | .83 | 1.00 | | | | | | | |
| 4. | .14 | .64 | .69 | 1.00 | | | | | | |
| 5. | .23 | .56 | .39 | .48 | 1.00 | | | | | |
| 6. | .07 | .41 | .33 | .00 | .39 | 1.00 | | | | |
| 7. | .47 | .83 | .73 | .41 | .39 | .60 | 1.00 | | | |
| 8. | .60 | .97 | .87 | .55 | .54 | .47 | .87 | 1.00 | | |
| 9. | -.33 | -.41 | -.60 | -.28 | .08 | -.20 | -.60 | -.47 | 1.00 | |
| 10. | .47 | .28 | .20 | .00 | .39 | .07 | .20 | .33 | -.07 | 1.00 |

Note: The above is a matrix showing the degree of agreement / disagreement between each pair of "voters". For example, the statistic for agreement between "voter" #1 and "voter" #3 is .47, and that between "voter" #2 and voter #3 is .83.

**Figure 4: Matrix of Rank Correlation Between Players**

## XII. CONCLUDING REMARKS

47. After some discussion, the co-chairs of the ARWG decided that the CDSP-generated result was acceptable as is without any modification. As such, the CDSP-generated prioritization of the new R&D major Army projects was presented to and used by the RDEC. The "voting" exercise had been a success. It had produced a reasonable and acceptable solution within the tight time constraints that had been externally imposed.

48. Although shortcuts were applied in this application of the CDSP methodology, it is definitely not recommended that other applications of the methodology utilize such shortcuts, unless absolutely necessary. If the shortcuts are utilized, the success of the consequent "voting" exercise is far from guaranteed.

49. It must be recognized that these shortcuts:

a. do not provide adequate opportunity for all "voters" and stakeholders to contribute to the formulation of the criteria to be used in ranking the projects, making it more likely that some essential criterion will be overlooked in the write-up of the project descriptions and in the "voting"; including representation from all stakeholder groups, when full representation by all "voters" is not practical, decreases the risk of criteria being overlooked or being ill defined;

b. do not provide adequate opportunity for "voters" to discuss and debate issues, and hence to benefit from each other's unique experience and knowledge prior to each round of "voting"; choosing "voters" who have broad experience and knowledge in the relevant issues may make discussion and debate less crucial;

c. do not provide adequate opportunity to brief the CDSP process to "voters" to ensure that they are comfortable with it and that they agree with its underlying assumptions; providing a briefing package on the CDSP and encouraging telephone queries should there be questions, may increase acceptance and familiarity with the methodology;

d. do not facilitate the building of consensus and "buy-in" from "voters", which is often of importance in a committee setting; encouraging and utilizing "voter" feedback in all facets of the "voting" exercise may help somewhat in this regard;

e. may force the choice of "voters" to be completed quickly, without debate on whether the "voter" composition is representative and fair; ensuring that all "voters" and stakeholders have an opportunity to comment on and influence the choice of "voters" may decrease the risk that "voter" composition is a cause of lack of acceptance of the CDSP-generated results;

f. may result in project descriptions that are incomplete, or that follow different formats making comparison of projects by "voters" difficult; issuing clear, complete and detailed instructions to authors on the content and format of the project descriptions may help ensure that "voters" have all the essential information they need in a format that is easy to use;

g. increase the risk that "voters" will be making decisions without knowledge of all the critical information required to make an informed decision on how to rank the projects; addressing (f) adequately as well as encouraging "voters" to ask for additional information when it is required, helps ensure "voters" are adequately informed;

h. may force "voters" to complete their rankings without adequate time to properly study the project descriptions and the "voting" issues; "voters" should only submit "votes" if they feel that they have had adequate time to provide an individual ranking which they are comfortable with;

i. may result in a prioritized list which is unacceptable due to a lack of consensus among "voters" during the first round of "voting", creating difficulties if an answer is needed and time is not available for "voters" to discuss and debate issues and participate in a second round "vote"; even if the prioritized list generated from the first round "vote" is not acceptable, the CDSP process generates information that is useful in decisions concerning the final ranking that is to be decided upon (please refer to section III for details).

50. Finding solutions to "real world" problems may mean working under severe time and resource constraints. This, in turn, forces shortcuts to be taken in the application of the methodologies to be used to arrive at a solution. Judgements must be made in terms of what shortcuts are to be used to provide a useful and "good" (but not necessarily "best") solution within the externally imposed deadlines. The May 99 R&D project prioritization exercise has shown that the application of the CDSP is as much an art as a science. It has also shown that including representatives from all stakeholder groups in the "problem definition" stage, in this case representatives from both the R&D and operational communities, is important to ensuring that "voters" have the information they need to make informed decisions. This in turn helps ensure that the "voting" exercise has a fair chance of succeeding.

## REFERENCES

1. Minutes of the Army Research Working Group Meeting held 5 May 99

2. Prioritization of Land Force Equipment Goals: An Application of the Consensus Decision Support Program (CDSP), by Mira Halbrohr, ORA PR689, August 1994

3. Looking Forward, Staying Ahead 1999-2004, Defence Research and Development Board, September 1998

4. Land Force Strategic Direction and Guidance, Parts I and II, 1998

5. Preliminary Report on Consensus Procedures for Priority Ranking by a Committee, by Ed Emond, DMS SN 4/87, July 1987

6. A Consensus Procedure for Committee Decisions, by Ed Emond, ORAE PR 448, December 1987

ANNEX A
ORD PROJECT REPORT PR 9913
AUGUST 1999

**DEFENCE R&D STRATEGY, MAY 1999 RETURN SHEET**

Name
Rank
Position
Phone (Include Area Code)

ORDER PROJECTS BY PRIORITY, WITH HIGHEST PRIORITY PROJECT LISTED FIRST, AND USE [ TO INDICATE TIES AND MULTIPLE TIES (IF ANY):

| PRIORITY | PROJECT SERIAL NUMBER | PROJECT NAME | COMMENTS CONCERNING RANKING CHOICE |
|---|---|---|---|
| 1 (highest priority) | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 (lowest priority) | | | |

Note: You must rank **all** the projects.

**ADDITIONAL COMMENTS** (Concerning Ranking Criteria, Project Report Format, Process Used for Prioritization)

ANNEX B
ORD PROJECT REPORT PR 9913
AUGUST 1999

## CONSENSUS DECISION SUPPORT PROGRAM (CDSP) SYNOPSIS

The CDSP is a decision support methodology developed in the late 1980's by Mr. Ed Emond, a defence scientist in ORD. It has been implemented as a computer program that runs on a PC.

CDSP has been successfully applied in several arenas. For example, the Army used it for the LFES I exercise, the Communications and Security Establishment (CSE) used it in several exercises involving the prioritization of projects for funding, and the Navy used it to study fleet mix options.

The CDSP applies the diverse expertise, experience, knowledge, and points of view of the "voters" who each produce individual rankings of alternatives. The CDSP combines these individual rankings to produce a single prioritized list of the alternatives which represents the combined best judgement of all the "voters" involved. The complex tradeoffs and risk analysis required to generate rankings are done individually by human experts. No artificial weights or rating scales are used. There is no requirement to quantify by how much any alternative is preferred over another, and ties and multiple ties are allowed. Each "voter" is given an equal voice in the final outcome. In addition to producing a consensus ranking, CDSP produces useful statistics that can be used to analyze results and help guide further discussions.

In order to obtain meaningful results while using CDSP, it is important that the CDSP assumptions be met. For more detailed information concerning these assumptions and other facets of the CDSP, readers may consult references 2, 5, and 6 or they may contact DGOR.



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This report documents the prioritization of six new major research and development (R&D) projects by the Army Research Working Group (ARWG) in May 99. The "voting" exercise was conducted using the Consensus Decision Support Program (CDSP) methodology.

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Research and Development Projects
Prioritization Methodology
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